IMPROVING SEASONAL CLIMATE FORECASTS FOR MORE EFFECTIVE DRYLAND PRODUCTION SYSTEMS

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Introduction

Can knowledge of climatic conditions and associated rainfall variability at time scales of several seasons to decades be used to improve cropping systems management? This is a question at the core of this GRDC/CRDC funded research project.

There have been many examples where farming practices in Australia were originally developed during periods of above-average rainfall. Research has found that in later decades there were periods when reliable rainfall patterns did not persist. In some cases this led to environmental degradation, a rapid decline in productivity, and increased farm abandonment, all of which have been at a great cost to individuals and the nation as a whole (McKeon et al., 1990). Obviously, management strategies that have been developed during periods of low rainfall might not be appropriate during times of higher rainfall. Understanding such climatic cycles might provide an opportunity to put historical experiences into perspective and to choose management strategies that are appropriate for current climatic conditions.

Climate variability has considerable consequences for Australian crop production and its management. The incorporation of seasonal climate forecasts with higher skill and longer lead times has the potential to positively influence farm decisions, resulting in higher farm incomes and a reduction in economic and environmental risks. Weather forecasts have long been used routinely for operational decisions on farms (eg scheduling of operations such as sowing and harvesting). Over the last 10 years seasonal forecasts have also become increasingly important for tactical decisions such as fertiliser rates, sowing times, crop choice and logistical planning. Terms such as 'SOI' and 'sea surface temperatures' have become part of the rural vocabulary.

Whilst work on how best to use such probabilistic information of El Niño/Southern Oscillation (ENSO) related climatic conditions for the next growing season continues, this GRDC/CRDC project aims to incorporate climate forecasts with possibly higher skill and even longer lead times into strategic decision making. Recent work on phenomena such as the IPO (Interdecadal Pacific Oscillation; Power et al., 1999) and related patterns (Allan, 2000) indicates such potential, but requires further work and scrutiny (Meinke et al., 2000).

Simulation analyses of various cropping systems management options are an objective means to quantify the value of such climate signals. They allow an impact analysis of climate variability on **today's** management practices. While producers only ever experience one particular outcome in any season, simulations allow us to quantify what the outcome of the same practice would have been under different climatic conditions. This also provides us with the ability to discriminate among those climate signals; ie simulations can be used to differentiate between ENSO related seasonal variability and longer term patterns such as the IPO.

On the farm the potential strategic decisions that could be based on such information include issues such as optimisation of cropping intensity, reduction of erosion risks and other environmental hazards, more efficient use of resources, capital investment decisions and guidelines on how to select more profitable and sustainable cropping systems in response to a forecast. However, before such improvements can be realised, we need to demonstrate that our emerging ability to predict climate variability with higher accuracy and longer lead times can really result in such benefits on farms. Hence, this paper compares the financial outcomes and potential soil loss of two fixed rotation strategies, with the aim of selecting an optimal rotation by strategically switching between the two rotations, based solely on the IPO, ie without accounting for seasonal, ENSO related climatic variability as indexed by the SOI.

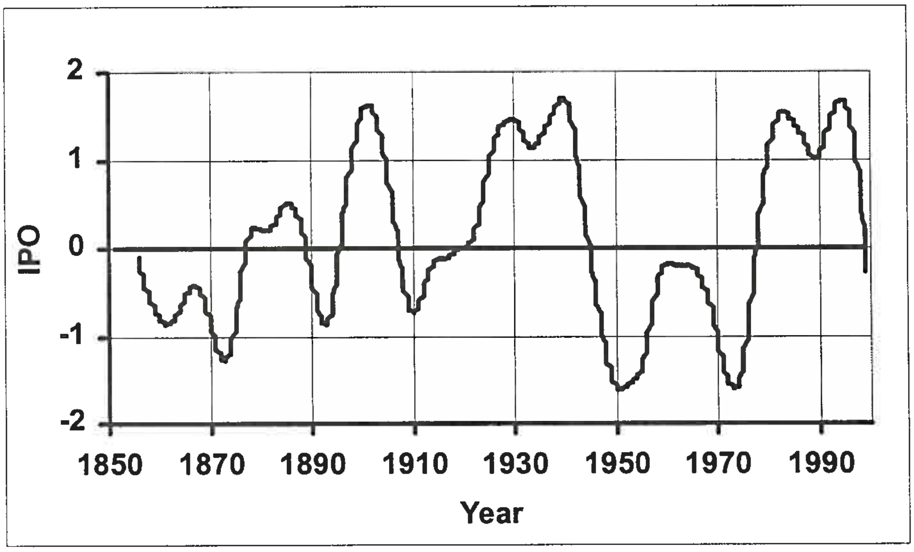

Fig. 1: Values of the IPO from 1850 to 1999

Methods

The IPO is a coherent, inter-decadal oscillation in sea-surface temperature (SST) anomalies of the Pacific (Power et al., 1999). Similar, but independent analyses of near-global SSTs and atmospheric pressure fields yield similar results (Allan, 2000). These patterns vary at time scales of 15 years or more (Fig. 1). Underlying mechanisms and the predictability of these patterns are currently being investigated (Meinke et al., 2000) and although results are, as yet, inconclusive persistence of these patterns for long time periods make such information attractive for decision making.

In this study, we compare two four-year rotation strategies, namely a cereal rotation (C) and a cotton rotation (CO) with the aim to find the optimal combination based on the IPO. APSIM was used to simulate yield based on soil properties and climate data from northern NSW (Goondiwindi – Moree). The model was run over 100 years and the gross margin for each year was estimated using June 2000 costs and prices. Gross margins (GM) for each rotation were calculated separately for years with either positive or negative IPO values, resulting in four cumulative distribution functions (Fig 2). We found that when the IPO was negative, GM from the cotton rotation generally exceeded those from the cereal rotation, indicating that the cotton rotation is likely to yield higher returns in a negative IPO year. Conversely, when the IPO is positive, the cereal rotation was more likely to result in a higher gross margin.

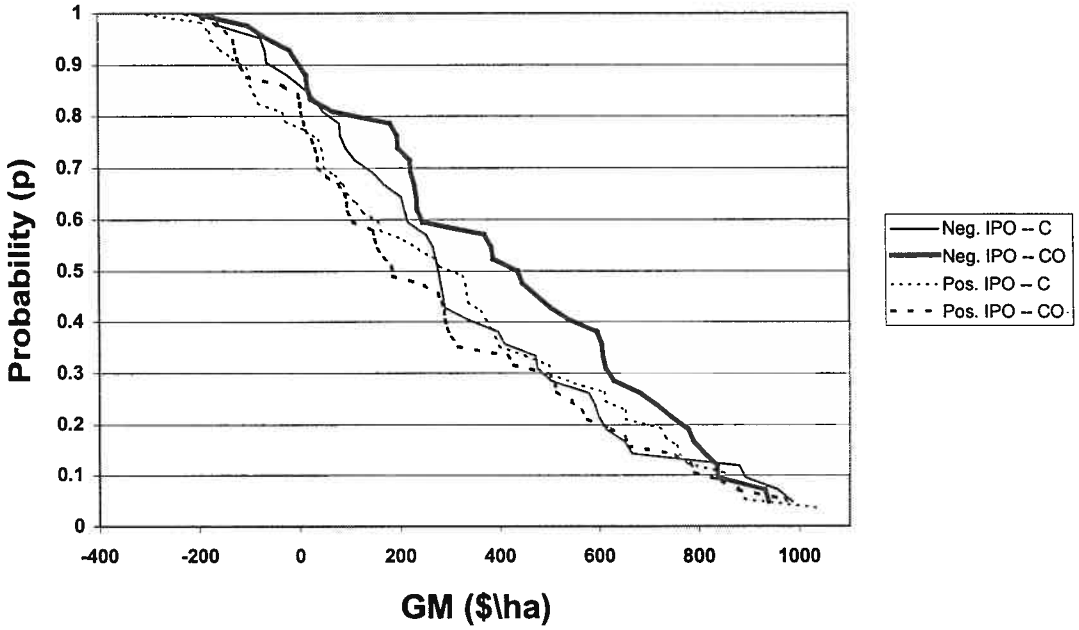

Fig. 2: Cereal (C) and Cotton (CO) rotation gross margin CDFs based on the phase of the IPO.

Fig. 2 suggests that 'the optimal strategy' might be to select rotations based on the value of the IPO, so that a cereal rotation is implemented during positive IPO year and a cotton rotation is used in a negative IPO year. While this scenario analysis is not realistic from a producer's perspective (after all, it does neither account for year-to-year price variability nor does it take a seasonal outlook into consideration), it highlights the impact that decadal rainfall variability has on the economic performance of farms.

Based on Fig. 2 we calculated the GM that would be obtained from the 'optimal strategy', namely growing cereals in positive IPO years and reverting to a cotton-based rotation in negative IPO years. The analysis was repeated using two additional levels of pricing, set at 30% above and below this year's prices, respectively, to determine price sensitivity of the analysis. This scenario, however, did **not** alter the price ratios of the various crops. This would obviously significantly alter the outcome of the analysis.

In addition to the economic performance, it is important to consider environmental and sustainability related consequences of cropping systems management. One of these possible consequences is soil loss due to erosion. This is obviously very location specific and depends on many factors such as soil type, slope and surface and stubble management. Soil loss was simulated for each rotation strategy using parameters for a grey cracking clay. Our example is based on slightly sloping conditions and a moderate degree of stubble retention. It will vary considerably from paddock to paddock and is used as an example only.

Results and Discussion

The use of the IPO increased median gross margins by 21%, when compared to the fixed rotation strategies (Table 1). However, this gain must be weighed up against possible soil losses. The 'optimal strategy' increased soil loss by 195% when compared to the fixed cereal rotation. While this value is high, it is far better than the cotton rotation, which increases soil loss by 357%. Changes in surface management and increased stubble retention might well change these figures considerably.

Table 1: Median gross margin and soil loss comparison for 3 rotations using current prices. Values are calculated on a financial year basis and represent an average over the four years of each rotation.

	Cereal	**Cotton**	**IPO**
Median Gross Margin ($/ha/yr)	277	276	334
Median Gross Margin (% of Base Value)	100	100	121
Median Soil Loss Index (% of Base Value)	100	357	195

A similar gross margin trend occurs regardless of price fluctuations (Table 2). High commodity prices marginally improve the cereal rotation against the cotton, although the IPO based strategy is still the better option. The preferred fixed rotation strategy is reversed when prices are high, with cotton becoming marginally more economical. The low-prices scenario amplifies the affect of the IPO-based strategy with an increase in median gross margin of 38% (Table 2). We stress, however, that results can be very different if commodity prices chance independently.

Table 2: Median gross margin comparison for high and low prices.

	High Prices			*Low Prices*		
	Cereal	**Cotton**	**IPO**	**Cereal**	**Cotton**	**IPO**
Median Gross Margin ($/ha/yr)	440	421	500	88	93	122
Median Gross Margin (% of Base Value)	105	100	119	100	106	138

Conclusions

The study clearly showed a significant economic and environmental impact of decadal climate variability. There could be significant economic advantage in using indices such as the IPO for strategic decision making. It remains a considerable challenge to operationalise such information and to combine it with our ENSO based understanding of seasonal variability.

Acknowledgments

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